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OPTIMIZATION OF CLAY PROPERTIES FOR SELECTING BRICK MOLDING METHOD

V. P. Rat'kova,[1] N. D. Yatsenko,[1] G. N. Ivanyuta,[1] and P. B. Nechaev[1]

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The main properties of argillaceous materials governing methods for producing ceramic bricks are identified. The properties of ceramic mixtures based on Central Asia clays are optimized and recommendations for brick production technology are issued.

The choice of a brick molding method depends on the properties of argillaceous materials and the technological production scheme.

The optimization of properties in the present work was carried out for clay materials from the Semafornoe and Alma-Atinskoe deposits.

The argillaceous materials of Central Asia deposits is represented by loess and lean loam.

Ceramic products based on them have unsatisfactory crack resistance and strength and, therefore, require special methods for preparing molding powder, drying, and in some cases firing of articles.

The results of studying the physicochemical, technological, and firing properties of argillaceous materials are listed in Tables 1 – 6.

[1] South-Russia State Technical University (NPI), Novocherkassk, Russia; North-Caucasus NIIstromtekhnika Research Institute, Russia.

The clay from the Semafornoe deposit is a dense argillaceous rock weakly boiling under the effect of a 10% hydrochloric acid solution. Alma-Atinskoe clay is a lean loam with a loose structure, of a yellow-brown color, intensely boiling up under the effect of the acid.

According to their granulometric compositions, both materials belong to highly dispersed dust-like clays.

The mineral composition of the materials was determined using x-ray structural analysis and the method of selective tinting of clay.

The main clay-forming material in clay from the Semafornoe deposit is kaolinite with a substantial content of hydromica, whose composition approaches baydellite. The Alma-Atinskoe material is monomineral, as it mainly consists of ferrohalloysite, which belongs to the kaolinite group of minerals.

TABLE 1

Argillaceous material from deposit	Mass content, %								Free quartz content, %
	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	CaO	MgO	R_2O	calcination loss	
Semafornoe	63.60	16.20	0.95	5.80	1.40	2.00	3.80	6.00	30.00
Alma-Atinskoe	53.40	12.60	0.80	4.00	10.60	2.00	4.60	10.40	27.20

TABLE 2

Argillaceous material from deposit	Content, %, of fine fractions			Content of grain inclusions, partial residue, %, on sieves with cell size, mm			
	sandy (0.05 – 0.2 mm)	dustlike (0.05 – 0.025 mm)	argillaceous (0.005 – 0.001 mm)	2	1	0.5	0.25
Semafornoe	3.0	56.2	40.8	0.08	0.05	0.10	0.01
Alma-Atinskoe	3.0	60.0	5.0	0.08	0.14	0.34	0.04

TABLE 3

Argillaceous material from deposit	Clay moisture, %		Plasticity number	Classification of clay materials
	at the lowest yield point	at rolling boundary		
Semafornoe	37.40	21.70	15.7	Medium plasticity
Alma-Atinskoe	20.95	15.75	5.2	Low plasticity

TABLE 4

Argillaceous material from deposit	Molding moisture, %	Air shrinkage, %	Drying sensitivity coefficient	Drying sensitivity group
Semafornoe	26.7	10.7	> 2.0	High sensitivity
Alma-Atinskoe	17.0	5.0	0.3	Low sensitivity

TABLE 5

Argillaceous material from deposit	Firing temperature, °C	Total shrinkage, %	Water absorption, %
Semafornoe	950	1.40	15.0
	1000	3.10	12.2
	1050	5.40	10.9
	1100	5.70	8.9
	1150	–	6.4
Alma-Atinskoe	950	0.07	22.8
	1000	0.04	20.0
	1050	0.02	14.2
	1100	0.21	8.3
	1150	6.20	4.0

TABLE 6

Argillaceous material from deposit	Temperature, °C, of				
	beginning of sintering T_a	sintered state T_b	over-burning T_c	sintering interval $T_c - T_a$	sintered state interval $T_c - T_b$
Semafornoe	950	1150	1250	200	100
Alma-Atinskoe	1000	1150	1170	70	20

The material from the Semafornoe deposit is medium-plasticity clay, but its high drying sensitivity prevents its being recommended for plastic molding of bricks.

In semi-dry molding, samples made from this material have wide sintering and sintered state intervals (200 and 100°C, respectively), which is a positive factor for selecting a firing regime. However, since the raw material has high sensitivity to drying, it is impossible to combine drying and firing inside a single plant. Consequently, a special cyclic drying regime needs to be developed.

Drying can be carried out in a drying kiln. The first stage of drying is a temperature rise up to 30°C, leveling the temperature and moisture on the brick surface and across the brick section. After reaching a relative moisture of 92 – 94% moist air is pumped off and the second drying stage starts, i.e., heating up to 70°C while moisture decreases from 76 to 15% due to the removal of moist air. The permissible moisture after drying is 2.5 – 5.5%.

The properties of fired samples dried according to the cyclic regime are listed in Table 7. Good results have been obtained.

The example of clay from the Semafornoe deposit suggests that in choosing a brick-molding scheme it is necessary to take into account such basic clay parameters as its mineralogical composition, plasticity, drying sensitivity, and its sintering interval. Special attention should be paid to the scheme of drying molded articles.

The Alma-Atinskoe argillaceous material has low plasticity, low drying sensitivity, and admits of semidry molding of brick.

Comparing the technological schemes of semidry and plastic molding, it should be noted that with a similar energy consumption per 1 million conventional bricks the amount of machinery in semidry molding is nearly 3 times higher and the labor consumption is 26 – 30% lower than in plastic molding. The amount of water to be removed in semidry molding is 4 times lower than in plastic molding, which allows for 26 – 30% fuel saving (converted to conventional fuel). The semidry batch preparation requires 30% less production space and 20 – 24% less personnel. However, since Alma-Atinskoe clay has very narrow sintering and sintered state intervals, it is necessary to develop a more complex composition for the molding powder (additives to the batch) or to select a granulometric composition.

TABLE 7

Samples from clay material from deposit	Firing temperature, °C	Total shrinkage, %	Water absorption, %	Density, kg/m^3	Porosity, %	Strength, MPa		Color
						compressive	bending	
Semafornoe	950	1.4	14.8	2123	26.2	16.4	2.9	Brown
	1000	3.0	12.0	2157	23.8	17.0	3.1	Red brick
	1050	5.4	10.5	2327	17.6	22.3	4.3	Red-brown
Alma-Atinskoe*	950	0.7**	21.4	1620	39.4	7.8	1.1	The same
	1000	0.02**	19.4	1700	33.6	9.0	1.5	Red brick
	1050	0	13.6	1880	26.5	22.1	3.3	Red-brown

* Samples from fractionated batch.

** Increase in size.

In our research we used the method of selecting a granulometric batch composition for this clay. The best parameters were registered in samples that contained 30% fraction of 3 to 2 mm, 30% from 2 to 1 mm, and 40% of the fraction less than 1 mm.

Samples made from molding powder of moisture 10% were compressed by the two-stage method with the unilateral load application. The experimental results are shown in Table 7.

The testing of samples made from Semafornoe and Alma-Atinskoe clay materials for their resistance to frost established that they meet the requirements of GOST 530–95; their frost resistance is equal to 25 cycles.

Thus, when studying clay materials in order to select a technology for making bricks with optimum parameters, it is necessary to identify the mineral composition, plasticity, drying sensitivity, and sintering interval taking into account certain specifics of clays.